

INTEROFFICE CORRESPONDENCE



Hawaiian Electric Co., Inc.

An HEI Company

November 1, 1993

To: Thomas C. Simmons
From: Debbie Fujikami *[Signature]*
Subject: Pumped Storage Hydro Feasibility Study

The following is our rough analysis to provide to Okahara & Associates, Inc. (Lou Lopez) for their pumped storage hydro feasibility study.

Objective

The objective of this analysis is to determine, as a first step in the pumped storage hydro feasibility study, how a pumped storage hydro unit fits into the HECO system in the year 2005, in terms of daily versus weekly cycling, pumping and generating hours, and size (MW) limits.

Conclusions

Pumped storage hydro (PSH) units have the potential to save fuel for the HECO system. Daily cycling of a PSH unit intuitively makes sense because of the daily pattern of load. Daily cycling is supported by the analysis which shows more fuel savings with daily cycling than weekly cycling.

The number of pumping hours is about 8 (around 10 p.m. to 6 a.m.) and the number of generating hours is up to about 14 (around 7 a.m. to 9 p.m.). Based on the preliminary results, a 100 to 180 MW (generating) PSH unit could be utilized in 2005 on the HECO system. 180 MW is the upper limit so as not to increase spinning reserve requirements (spinning reserve is equal to the largest unit on the system which is presently 180 MW).

Analysis

GEPPS

GEPPS was run first to determine an addition schedule (see Exhibit 1). This run is with the new load forecast (8/27/93, revised in an 10/8/93 IOC) and follows the resource sequence from the IRP plan (REP-1). A combustion turbine (CT) is added in 1998 based on the current contingency plan. PROSCREEN and HEPROSIM runs were then made.

PROSCREEN

Five PROSCREEN runs were made based on the GEPPS plan.

1. No PSH unit.
2. 100 MW PSH unit in 2000. No second CT (2012). PSH has 1 cycle/week.
3. 200 MW PSH unit in 2000. No second CT (2012). PSH has 1 cycle/week.
4. 100 MW PSH unit in 2000. No second CT (2012). PSH has 5 cycles/week.
5. 200 MW PSH unit in 2000. No second CT (2012). PSH has 5 cycles/week.

These runs consistently show fuel savings with the PSH unit from the time the unit is installed. Also, the runs consistently show more fuel savings with 5 cycles/week (daily cycling) than 1 cycle/week (weekly cycling) from the time the unit is installed. Further, the runs consistently show more fuel savings with the 200 MW PSH unit than the 100 MW unit (the pumping and generating capacities were assumed to be the same). These results show that there is a potential for fuel savings by adding a PSH unit, and that in terms of fuel savings, daily cycling is preferable to weekly cycling, and a 200 MW PSH unit is preferable to a 100 MW unit.

A comparison of the annual generation for the four cases with a PSH unit shows that the PSH generates more with daily cycling than weekly cycling, especially when the coal-fired fluidized bed combustion (FBC) units are on the system. In the runs, FBC units are added in 2005 and 2009. The 200 MW PSH unit generates more than the 100 MW unit, especially when the FBC units are on the system. These results show that there is a potential to utilize a PSH unit more with daily than weekly cycling and that there is a potential to use more energy than that provided by a 100 MW PSH unit. Also, the FBC units appear to contribute greatly towards the energy stored in the PSH units.

HEPROSIM

HEPROSIM was run for the year 2005 based on the GEPPS plan, with no PSH unit. This run shows the hourly dispatch of units assuming the load profile in Exhibit 2. The run (see Exhibit 3) was supplemented with a tabulation of numbers at the bottom of the exhibit. These numbers show the capacity available (from HPOWER, AES, Kalaeloa, and a FBC unit) to store energy into a PSH unit, and the load on other units (Kahe 1-6, Waiau 3-8, G1-2 which represent Waiau 9-10, and G3 which is a CT) that may be displaced by a PSH unit. As shown in this exhibit, the PSH unit may be pumped during the late night and early morning hours (around 10 p.m. to 6 a.m.) and may generate during the day (around 7 a.m. to 9 p.m.). Note that the HEPROSIM run assumes that the FBC unit is base loaded, and this affects the Kalaeloa energy purchase amount.

According to these results, a PSH unit with a 215 MW pumping capacity is needed (see SUM (Off-Peak) in hour 3). Assuming the PSH unit will not displace the Kahe units, these results show a need for a PSH unit with a 135 MW generating capacity (see SUM w/o KAHE in hour 12). Note that since the unit loadings are for an hour, they represent energy (megawatthours) as well as load (megawatts). The pumping energy is in the ballpark of the generating energy (1331 MWH pumping versus 1496 MWH generating). Exhibit 4 graphs the hourly unit loading of Exhibit 3.

Attachments

cc: L. Ebisui/S. Higa
D. West

IRP GENPP 22, Studies/Statistics

GPD-cf

GEPPS Addition Schedule

HE-GEPPS MK 3 CAPACITY MODEL SUMMARY FOR 1993 THRU 2013

RUN PL191 /PU1877 /PB344 10/15/93

YEAR	PEAK	MINIMUM			INSTALLED		NORM YEAR		UNIT	CHANGE	CAUSE	WEEK	MONTH	UNIT RATINGS		
		SPECIFIED	ACTUAL	CAPACITY	EMER	NORM	MW	PCT						EMER	NORM	
START					1730	1669										
1993	1162	0	4.50	118.05	1730	1669	507	43.6								
1994	1167	0	4.50	81.47	1730	1669	502	43.0								
1995	1169	0	4.50	81.08	1730	1669	500	42.8								
1996	1179	0	4.50	55.64	1730	1669	490	41.6								
1997	1187	0	4.50	42.68	1730	1669	482	40.6								
1998	1205	0	4.50	229.35	1818	1751	546	45.3	G1	ADDED	DATE	1	JAN	88	82	
1999	1225	0	4.50	146.29	1818	1751	526	42.9								
2000	1246	0	4.50	60.94	1818	1751	505	40.5								
2001	1267	0	4.50	51.35	1818	1751	484	38.2								
2002	1290	0	4.50	20.47	1818	1751	461	35.7								
2003	1313	0	4.50	18.87	1818	1751	438	33.4								
2004	1336	0	4.50	10.40	1762	1695	359	26.9	H8	RETIRED		52	DEC	56	56	
					1705	1638	302	22.6	H9	RETIRED		52	DEC	57	57	
2005	1360	0	4.50	4.89	1909	1832	472	34.7	F1	ADDED	RISK	22	JUN	204	194	
2006	1384	0	4.50	7.08	1909	1832	448	32.4								
2007	1410	0	4.50	4.76	1909	1832	422	29.9								
2008	1438	0	4.50	4.69	1860	1783	345	24.0	W3	RETIRED		39	SEP	49	49	
					2010	1933	495	34.4	WA	ADDED	DATE	40	OCT	150	150	
					1955	1881	443	30.8	W9	RETIRED		52	DEC	55	52	
					1902	1831	393	27.3	W0	RETIRED		52	DEC	53	50	
2009	1467	0	4.50	5.08	1853	1782	315	21.5	W4	RETIRED		30	JUL	49	49	
					2003	1932	465	31.7	WB	ADDED	DATE	31	AUG	150	150	
					2207	2126	659	44.9	F2	ADDED	RISK	44	NOV	204	194	
2010	1497	0	4.50	24.20	2207	2126	629	42.0								
2011	1529	0	4.50	23.20	2150	2069	540	35.3	W5	RETIRED		52	DEC	57	57	
					2092	2011	482	31.5	W6	RETIRED		52	DEC	58	58	
2012	1561	0	4.50	4.94	2180	2093	532	34.1	G2	ADDED	RISK	14	APR	88	82	
2013	1595	0	4.50	5.04	2268	2175	580	36.4	G3	ADDED	RISK	48	DEC	88	82	

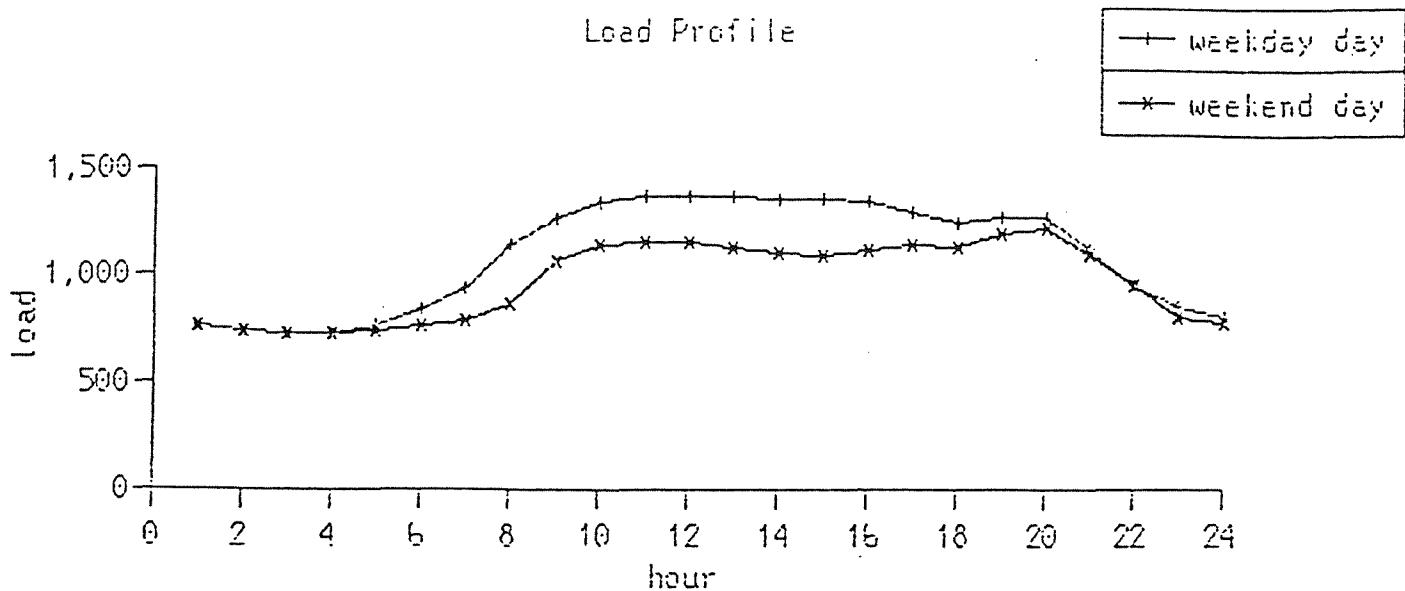
Trial 3

G1-G3: Simple cycle combustion turbine
 F1-F2: Atmospheric fluidized bed combustion
 WA-WB: Waiau repower
 H8-H9: Honolulu 8, Honolulu 9
 W3-W6, W9-W0: Waiau 3-6, Waiau 9-10

----- LOADPLOT - ENTRY PANEL -----
COMMAND ==>

This program will display your load profile for a given week and year.

Filename ==> PL191 Week ==> 31 Year ==> 2005 August



Enter PF3 to cancel operation.

Exhibit 2

Projected Hourly Unit Loading (MW)
2005

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Unit	Min *	Max	
System Load	758	736	725	728	763	831	941	1134	1263	1334	1357	1360	1358	1354	1348	1332	1288	1244	1260	1260	1119	950	847	801	H1	25	46	
A1 (AES)	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	A1	63	180		
F1 (FBC)	148	126	115	118	153	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	194	B2	65	180		
B2 (Kaleaoa)	65	65	65	65	65	92	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	180	108	65	F1	53	194
H1 (H Power)	25	25	25	25	25	45	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	46	25	25	K1	35	
X5 (Kahe 5)	70	70	70	70	70	70	102	111	116	119	119	119	118	118	116	116	113	109	111	111	100	73	70	70	K2	35		
X4 (Kahe 4)	35	35	35	35	35	35	35	55	64	69	72	72	72	71	71	69	66	62	64	64	54	35	35	35	K3	35		
K3 (Kahe 3)	35	35	35	35	35	35	35	68	84	92	92	92	92	92	92	92	88	80	83	83	65	35	35	35	K4	35		
K2 (Kahe 2)	35	35	35	35	35	35	37	61	67	70	72	72	72	72	71	70	68	65	67	67	60	41	35	35	K5	70		
K1 (Kahe 1)	35	35	35	35	35	35	35	54	66	73	76	77	76	76	75	72	69	64	66	66	52	35	35	35	K6	60		
W8 (Waiau 8)	35	35	35	35	35	35	35	57	64	67	69	70	69	69	69	67	66	62	64	64	56	37	35	35	W3	0		
W7 (Waiau 7)	35	35	35	35	35	35	35	57	64	68	70	71	71	70	70	68	66	62	64	64	55	35	35	35	W4	0		
X6 (Kahe 6)	60	60	60	60	60	60	60	80	103	116	123	124	124	123	120	116	110	98	102	103	76	60	60	60	W5	0		
W6 (Waiau 6)										20	22	23	23	23	23	22	22	21	20	20	20	20	20	20	20	W6	0	
W5 (Waiau 5)										20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	W7	35	
W4 (Waiau 4)										20	21	21	21	21	20	20	20	20	20	20	20	20	20	20	20	W8	35	
W3																									G1	0		
G3																									G2	0		
G1																									G3	0		
G2																												
Off-Peak																												Sum
H1	21	21	21	21	21	21	21																		0	21	21	168
A1	0	0	0	0	0	0	0																		0	0	0	0
B2	115	115	115	115	115	115	88																	0	72	115	850	
F1	46	68	79	76	41	0																			0	0	3	313
SUM (Off peak)	182	204	215	212	177	109																			0	93	139	1331
On-Peak																												
K1								0	19	31	38	41	42	41	41	40	37	34	29	31	31	17					472	
K2								2	26	32	35	37	37	37	37	36	35	33	30	32	32	25					466	
K3								0	33	49	57	57	57	57	57	57	57	53	45	48	48	30					705	
K4								0	20	29	34	37	37	37	36	36	34	31	27	29	29	19					435	
K5								0	32	41	46	49	49	49	48	48	46	43	39	41	41	30					602	
K6								0	20	43	56	63	64	64	63	60	56	50	38	42	43	16					678	
W3								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					0	
W4								0	0	0	20	21	21	21	20	20	0	0	0	0	0	0					144	
W5								0	0	20	20	20	20	20	20	20	20	20	20	20	20					240		
W6								0	0	20	22	23	23	23	23	22	22	21	20	20	20					259		
W7								0	22	29	33	35	36	36	35	35	33	31	27	29	29	20					430	
W8								0	22	29	32	34	35	34	34	34	32	31	27	29	29	21					423	
G1 (Waiau 9)								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					0	
G2 (Waiau 10)								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					0	
G3 (CT)								0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Sum		0			
SUM w/KAHE								2	194	323	393	417	421	419	415	408	392	347	302	321	322	178	►	4854		4854		
SUM w/o KAHE								0	44	98	127	133	135	134	133	131	127	103	94	98	98	41	►	1496				

* Minimum is zero for cycling and peaking units for the purpose of calculating the load that can be displaced by a pumped storage hydro unit.

Projected Hourly Unit Loading
2005

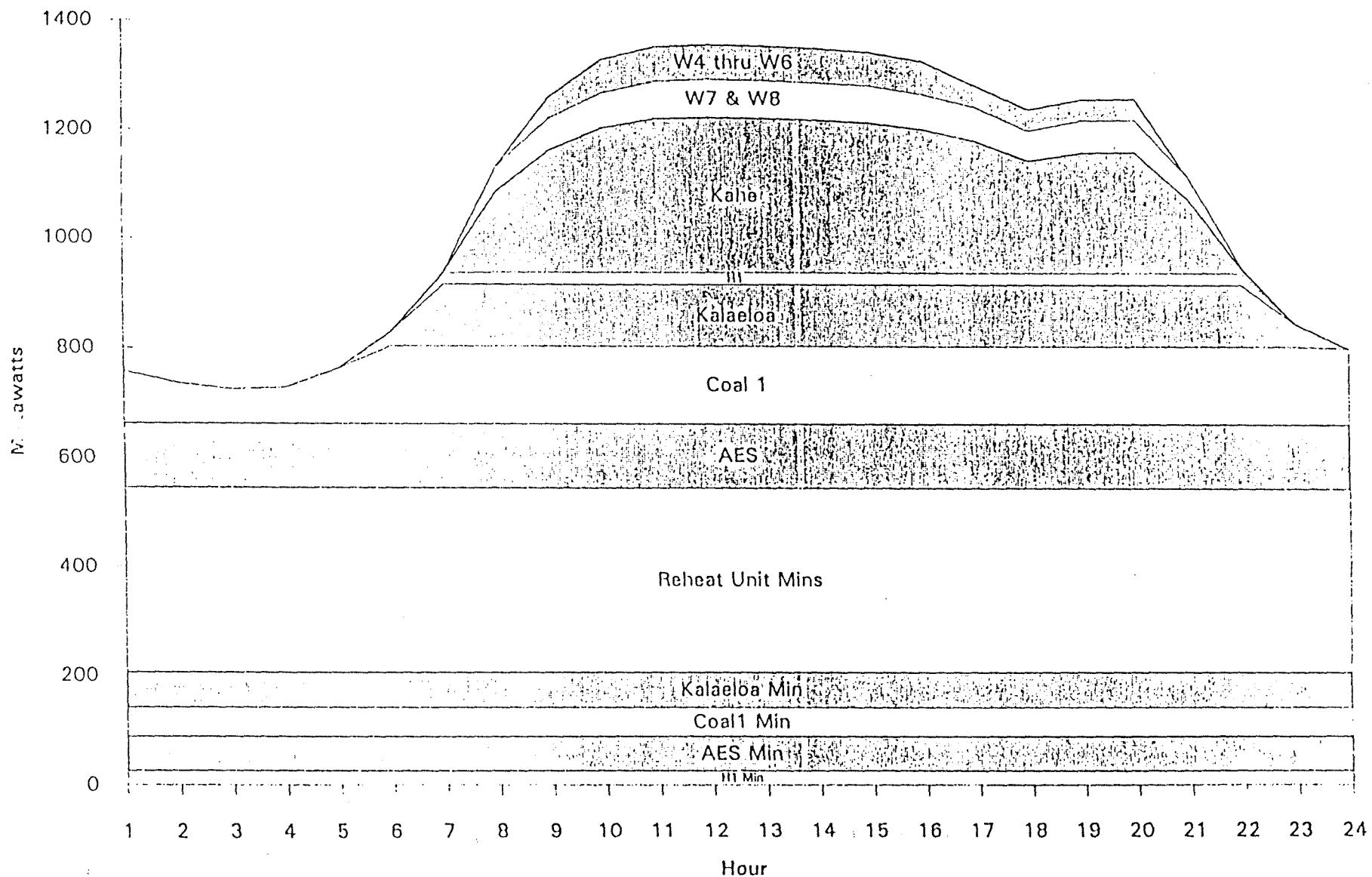


Exhibit 4